Energy Storage Research Priorities and Available Tools

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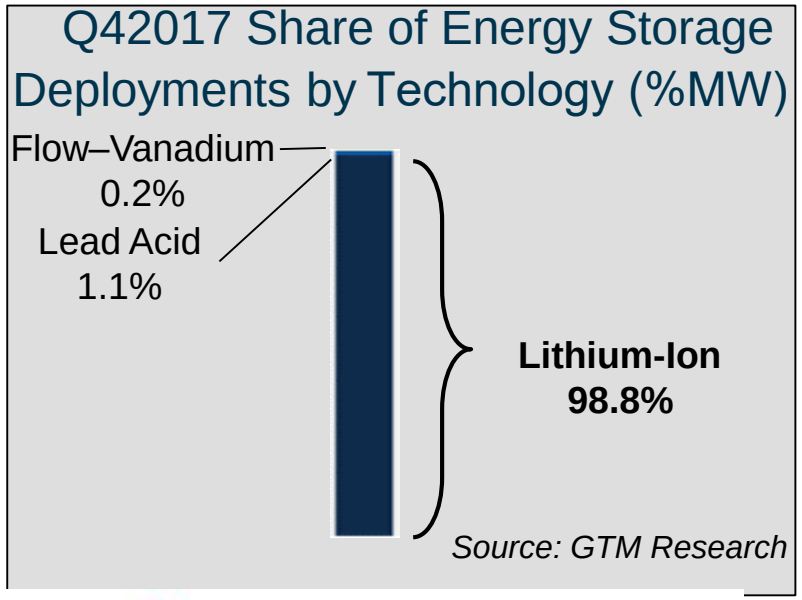
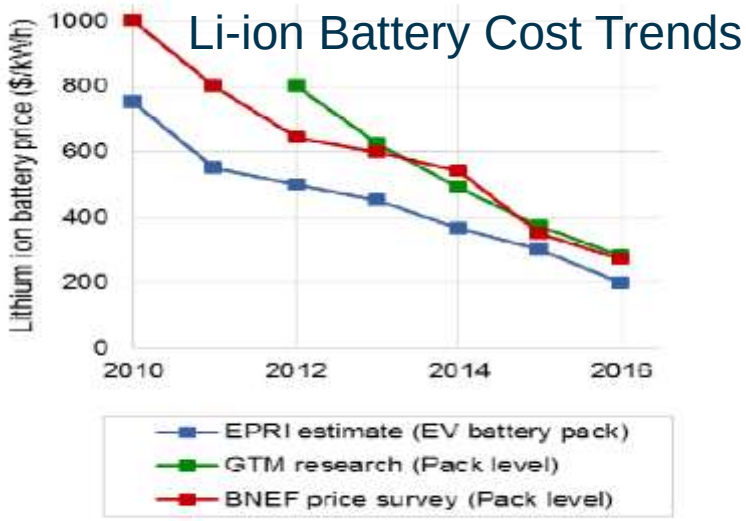
Agenda

- Industry status, drivers, and needs
- Continuing challenges and EPRI research priorities
- Publicly-available resources

Catalyst: Lithium-ion Battery Cost and Performance

- 50-75% cost reduction in 2-3 years
- Nearly all new advanced storage deployments are storage
- Driven by massive investment in R&D and manufacturing for portable electronics / EV's
- Cost reductions continue with scale-up of stationary energy storage products





Source: EPRI 3002010960

Figure 2. Lithium Battery Pack Prices, 2010-2016 [7, 16, 17]

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State policy tailwinds: U.S. state activity focused on storage

Integrated Resource Plans (IRP)

- GTM Research reports that almost 2 GW of storage was modeled in utility's Integrated Resource Plans during 2017. State-wide and utility focused regulations were passed that required energy storage to be evaluated in the integrated resource planning process.

Storage Procurement Targets

- New York became the 4th state behind California, Massachusetts, and Oregon to engage in setting an energy storage procurement target. New York targets 1500 MW by 2025. Shortly after the target was announced, the NY Governor announced $260 million in funding for storage deployment research.
- California targets 1.325 GW of grid-scale storage and 500 MW of customer-sited storage.

State Feasibility Studies

- Nevada, Maryland, and North Carolina all initiated studies in 2017 to understand the benefits, feasibility and role energy storage could play in their state.

Incentive Programs

California

- California's Self-Generation Incentive Program was re-opened in May of 2017. This program allocated $450 million of funds through the end of 2019 with 75% reserved for energy storage technologies. The SGIP offers a fixed price, long-term contract, similar to a feed-in-tariff, that applies to storage.

Maryland

- Maryland's state legislature passed the nation's first state tax credit for energy storage systems in 2017.

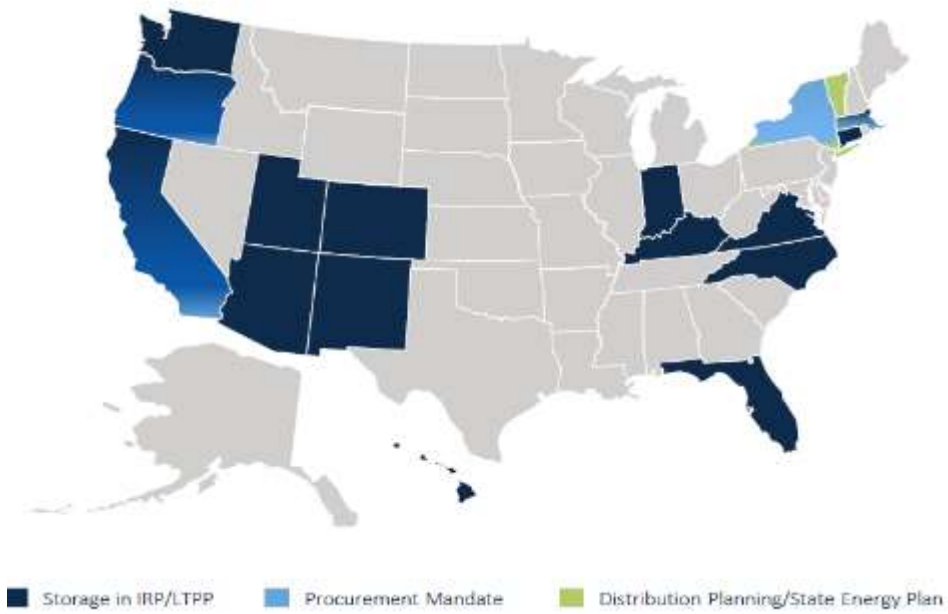
Massachusetts

- Developed the SMART program which provides incentives to solar deployed with storage.

New Jersey

- The Renewable Electric Storage Incentive Program gives incentives to those behind-the-meter storage systems that are integrated with class 1 renewable energy projects.

GTMR: States with Utilities including storage in Resource Planning or Rate Cases

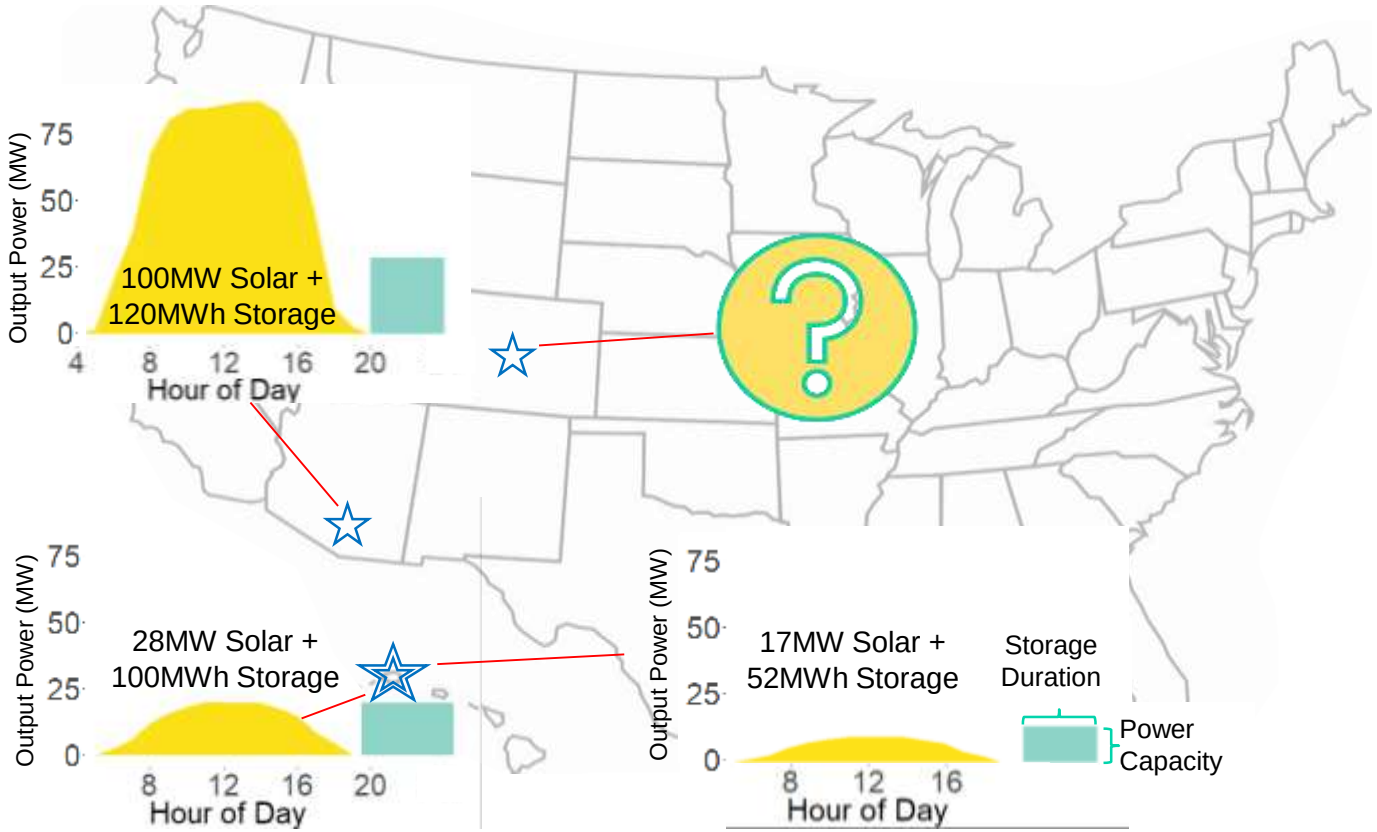


Source: Greentechmedia

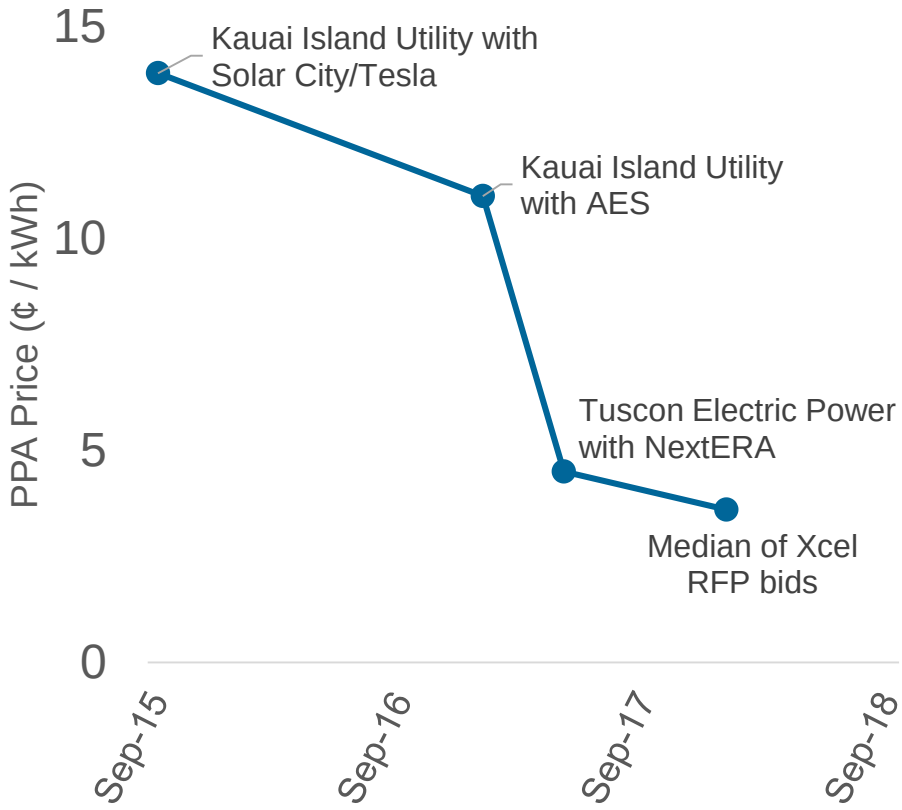
Storage economic and reliability assessments are key to planning and integration of projects

Trends in Solar + Storage: Delivered energy prices falling

Avg. July Solar Array Output and Energy Storage System Sizing

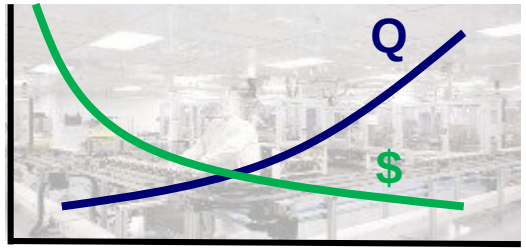


Solar + Storage PPAs



Strong downward trend in levelized cost of energy delivered (LCOE) -- but a flawed metric

Customer Storage Market Update and Adoption Drivers



- Global Deployment Update – Systems in Operation
  - Germany: 70k units
  - Japan: 60k units
  - Australia: 24k units

US Total Installed Base

- Res: 5.2k units, 26MW
- C&I: 1k units, 122MW

- Economic Transformation
  - Incentives: Evolving ITC and SGIP trends
  - Monetization: demand charge reduction and TOU time shift

- Technology & Societal Change
  - System harmonization and interoperability enhancements
  - Reliability: Nor'easter, Florida, Puerto Rico, Texas, Wildfires
  - Democratization of DER: EV, PV, Smart Appliances, etc.

Major US Federal Storage Regulation

FERC Order 841, February 2018

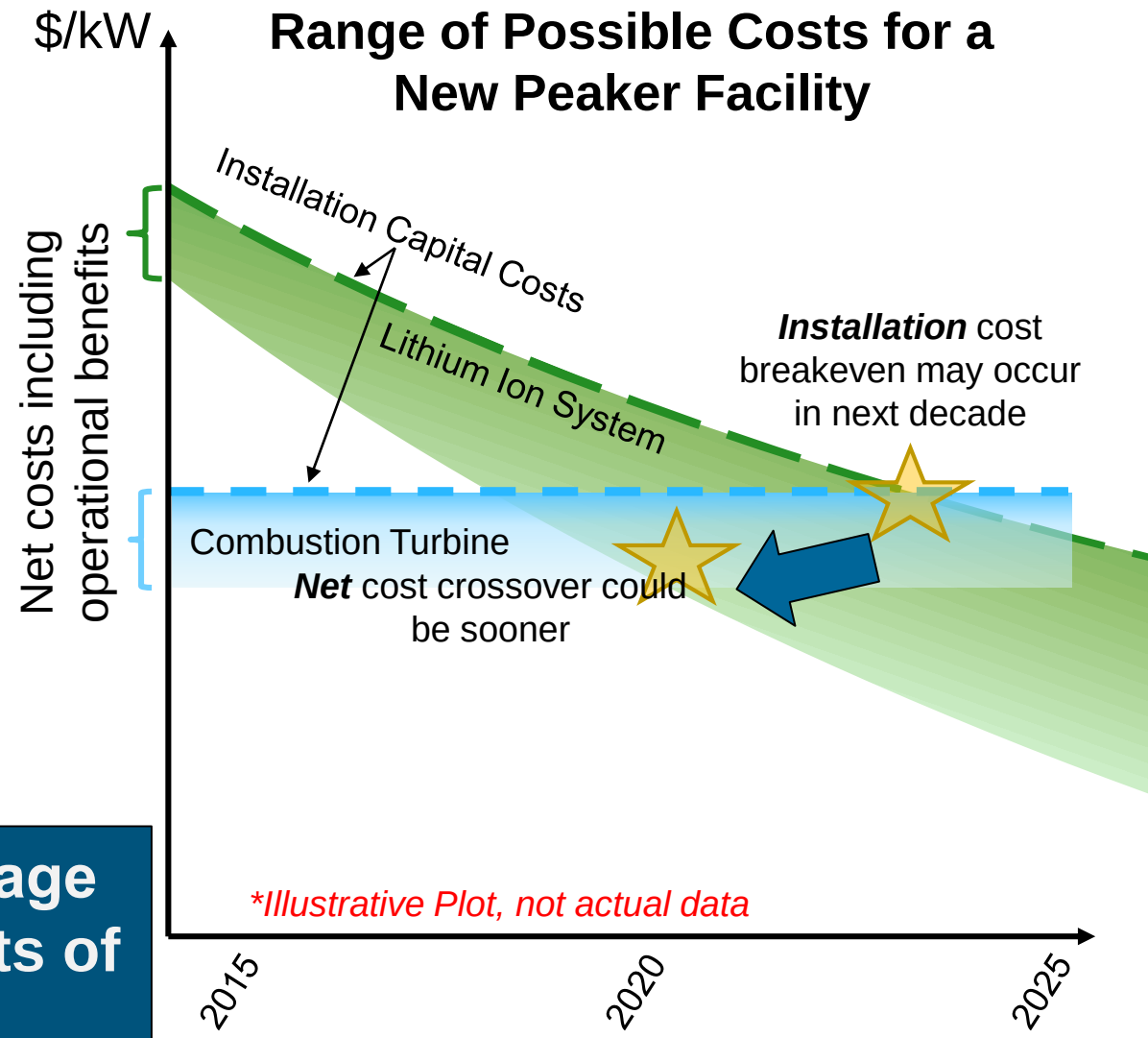
- Establishes energy storage as a major asset option
  - Allowed to participate in energy, ancillary services, and capacity markets when technically able

- Clarifies technical provisions for energy storage
  - Participate as wholesale buyer and seller
  - Minimum market participation size must be 100 kW or less
  - Ability of storage to set price as both a buyer and seller

FERC ruling expected to enable much broader storage participation. Numerous technical questions related to market design and software.

Tipping point for storage as the preferred peaking asset?

- Energy storage costs continue to fall
- Operational benefits matter – more appropriate to compare "net cost"
- The realizable value of energy storage is expected to increase as need for power system flexibility increases
- **In some cases**, commercial energy storage makes economic sense today and trends are positive for more cases in the future
- Peaker substitution is a large deployment opportunity in the next decade, accelerating the industry scale-up and learning curve



Key questions: How many "hours" of storage needed? What are the operational benefits of the future?

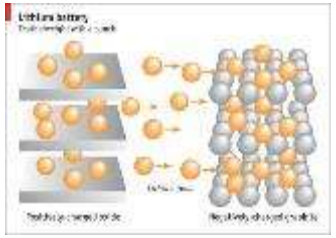
EPRI Energy Storage Research Program

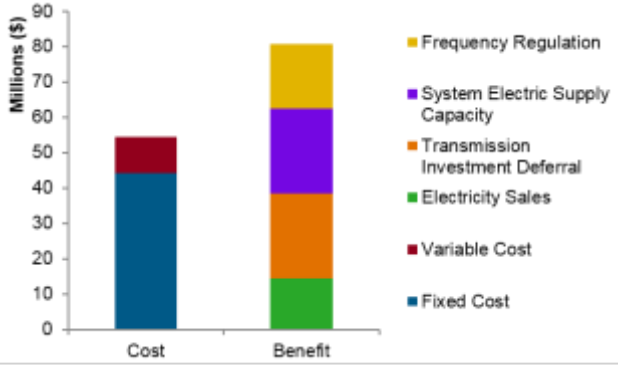
Scope and Priorities

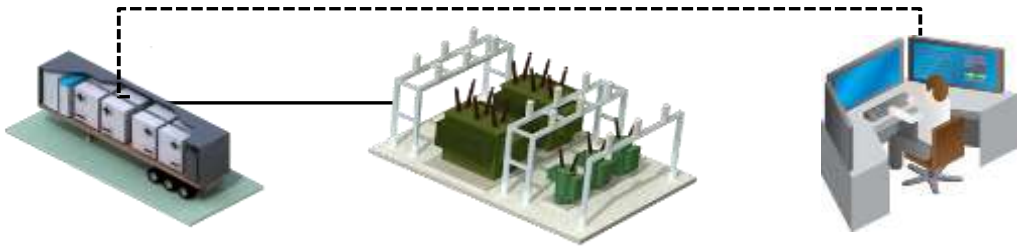
EPRI Storage Research Program Mission

Advance integration and use of safe, reliable, cost-effective and environmentally responsible energy storage

- Technology evaluation and guidance
- Analysis methods and tools
- Grid integration and deployment
- Industry engagement to advance common approaches







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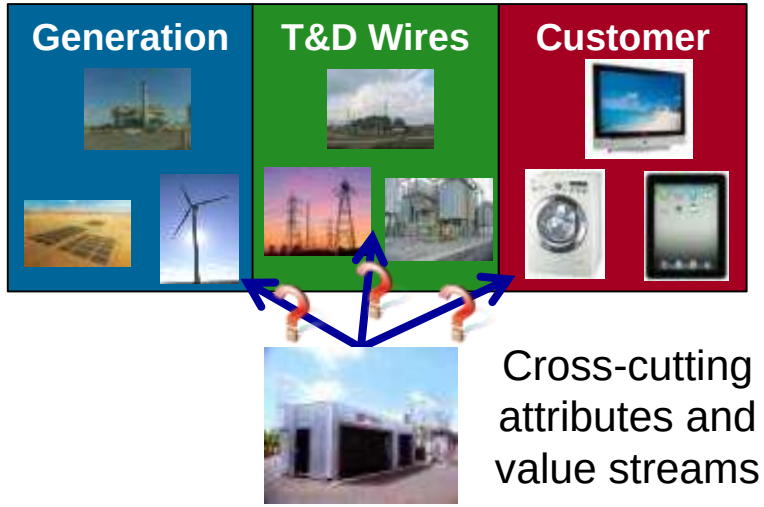
Featured Challenges and Research Priorities

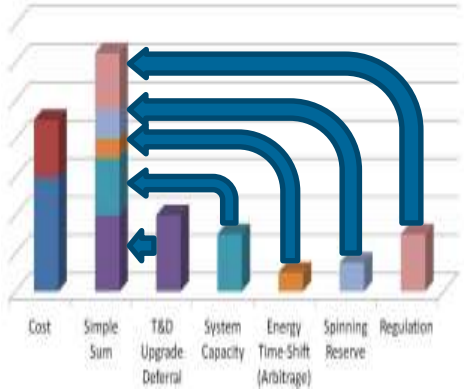
Analysis, Reliability, Grid Integration

Challenge #1: Energy Storage Analysis

- Unique energy storage attributes
  - Flexible and dispatchable
  - Limited energy – drives need for time-series modeling capabilities
- Value stacking is compelling, but still challenging
  - Need to ensure all reliability criteria are considered so tradeoffs are included
  - Existing grid planning / operations tools and processes are historically siloed
  - Rules and regulations are moving – technical requirements may change



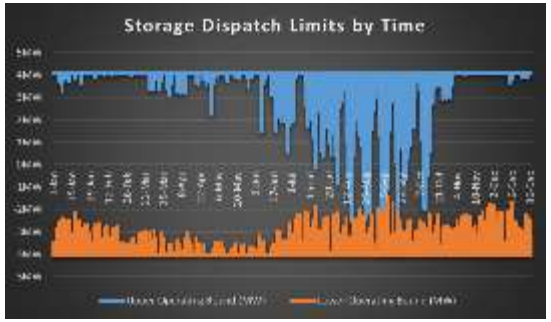
Cross-cutting attributes and value streams



More Value

More require-ments

Time-varying constraints at point of connection



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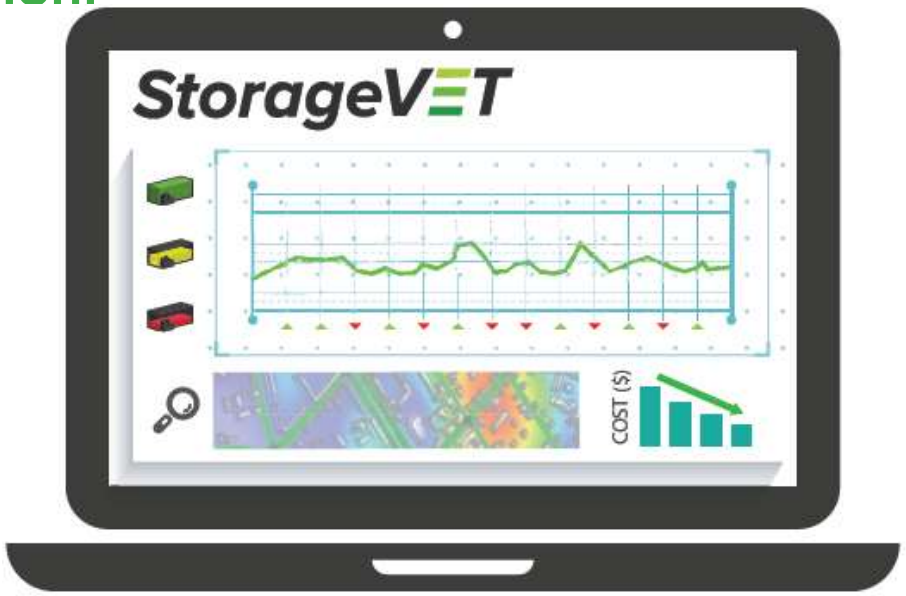
StorageVET® facilitates more complete storage analysis

Storage Value Estimation Tool (StorageVET®) is a free, publicly available, web-hosted energy storage simulation tool evolving through industry engagement

StorageVET Uses:

- Explore site-specific project value
- Communicate results across multiple stakeholders
- Customize cases:
  - All Grid Services
  - All Technologies and Sizes
  - Any Location
- Identify high value locations
- Explore stacked service operations with time-series simulation



Get started at storagevet.com

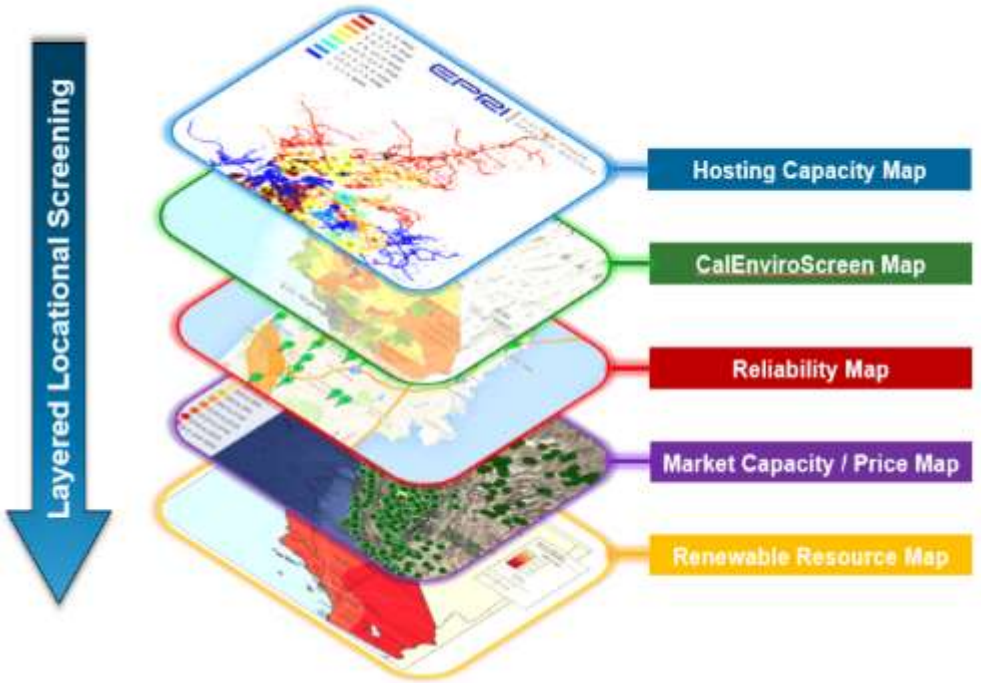
Continuing Evolution: Validated, Transparent & Accessible Microgrid Valuation & Optimization Tool *Starting May 2018: California Energy Commission Funded: $2M [GFO 17-305]*

Current Gaps

Current DER modeling tools lack:

1. Stacked benefit and optimizations of grid-tied DER
2. Interface with external analysis tools
3. Simple & intuitive user-interface for multi-scenario analysis
4. Multi-perspective valuation
5. Locational Screening based on metrics (e.g. hosting capacity)
6. Reliability/resiliency-based design

DER-VET is an expansion of StorageVET



Approach

Develop a Distributed Energy Resource Value Estimation Tool (**DER-VET™**), a publicly-available, open-source, microgrid valuation and optimization software tool

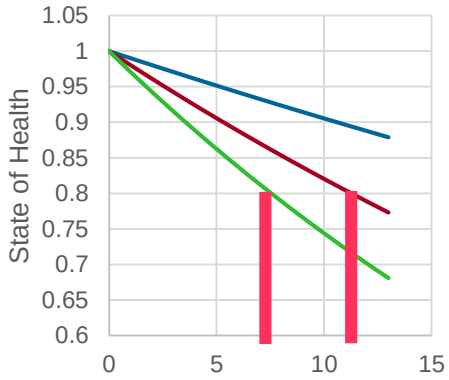
- Develop an **Integrated Analysis Framework**
- Create **Model Architecture & Algorithms**
- Develop open-source **Software Platform**
- Integrate with complementary tools for DER evaluation

Team: **EPRI (Prime), Xendee, SCE, PG&E**

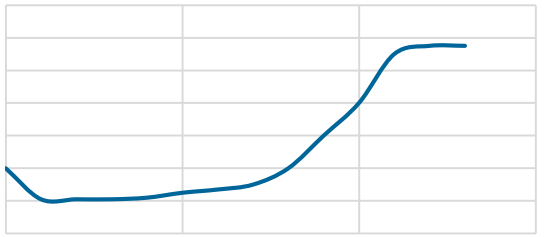
Challenge #2: Energy Storage Performance and Reliability

- Improvement underlying technologies is fast (e.g. Li-ion) and continuing…
- …but available commercial asset track record is short
- Degradation is an open question
- Reliability issues still need to be worked out – what “really” fails

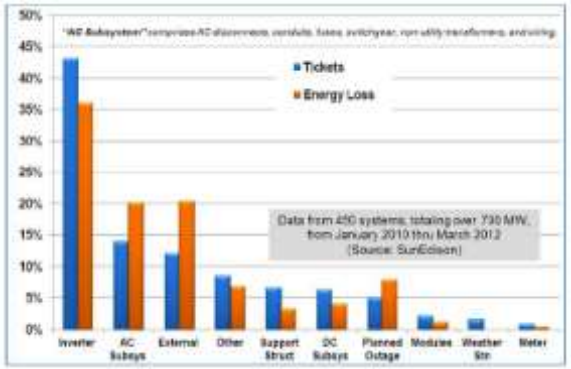
Degradation Profiles

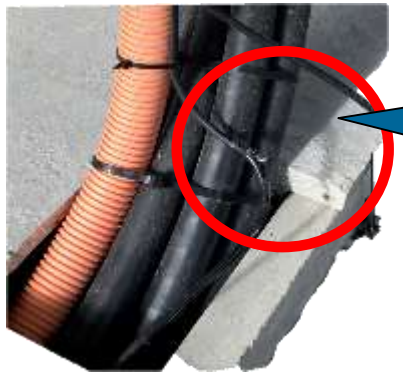


Component Hazard Rate



Example PV component reliability characterization – what is needed for storage

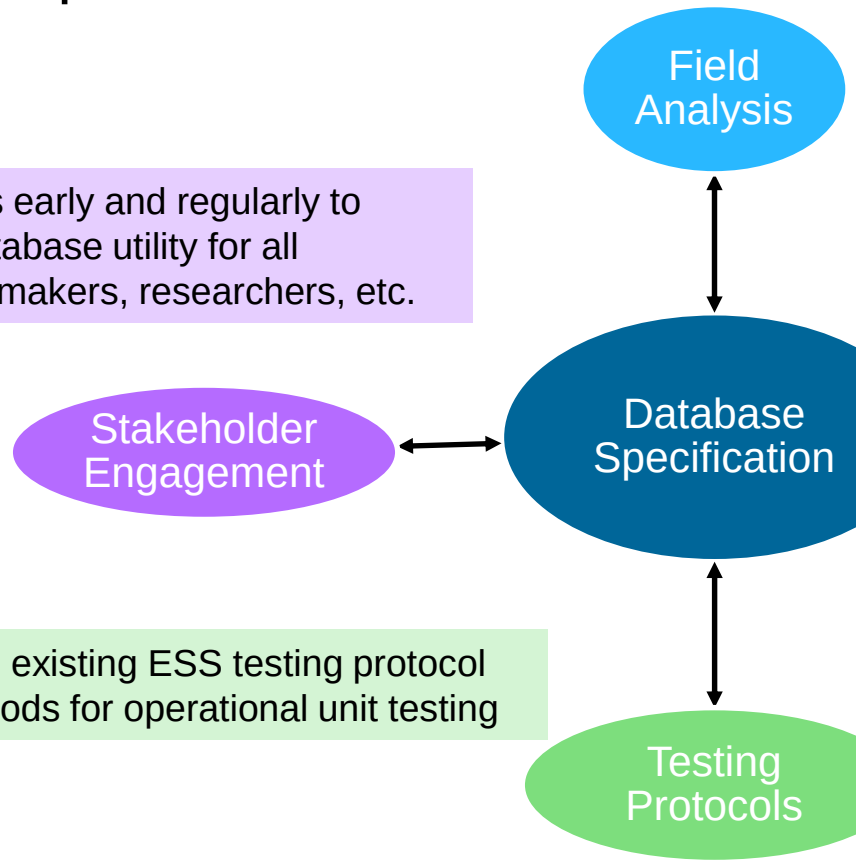




Rodent with a taste for plastic brings down a storage system

EPRI Storage Performance and Reliability Data Initiative

- **Goal**: Develop a database and track record for storage performance & reliability



- Automatically acquire data from ESS installations
- Analyze data to define and assess true performance and reliability metrics
  - Standby losses, degradation, sensor accuracy, etc.

- Engage stakeholders early and regularly to ensure maximum database utility for all
  - Utilities, policy makers, researchers, etc.

- Results assist ESS standards refinement efforts
  - Inform smarter, more effective policy

- Review and refine existing ESS testing protocol
  - Define methods for operational unit testing

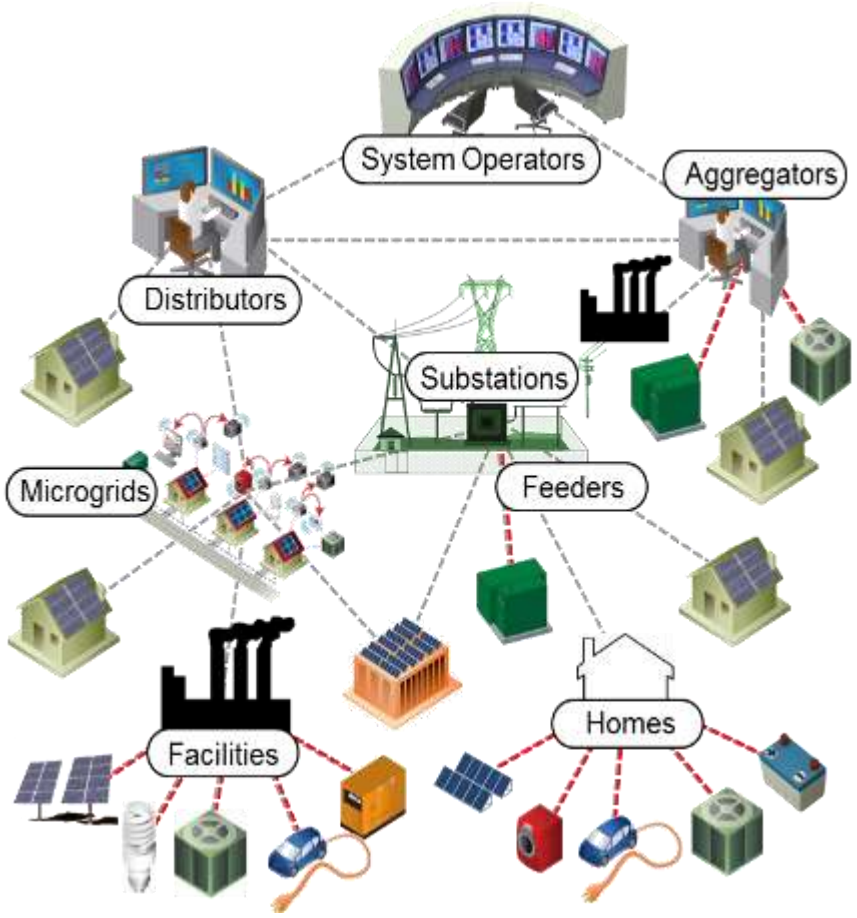
Project open to hosts and collaborators

Technical Lead: Steve Willard, swillard@epri.com

Collaborate to drive common data definitions and analyze shared field and lab test data to assess real world performance and identify root causes

Challenge #3: Grid Integration

- Integration with grid controls – supporting grid reliability and enabling stacked values
- Advancing distribution control capabilities – “DERMS”
- Cybersecurity and vendor remote access
- Protection, metering, communications
- Fire safety - Working with first responders, permitting authorities, etc.
- Developing implementation practices: Moving storage from R&D to Operations



Building a Utility Energy Storage Deployment Program: Pillars to Support Transition from R&D to Operations

OPERATIONAL DATA AND RELIABILITY ANALYSIS

- Specify common data formats
- Analyze test and field data
- Build a performance & reliability track record

Energy Storage Performance and Reliability Data Initiative

TECHNO-ECONOMIC MODELING

- Identify and screen opportunities
- Feasible and optimal location
- Design and operate for optimal lifecycle value

Energy Storage Analysis: Finding, Designing, and Operating Projects

IMPLEMENTATION PRACTICES

- Common guidelines for deployment across territories
- Customized tools for stakeholders
- Technical training

Energy Storage Implementation Practices: Building Organizational Capability for Deployment

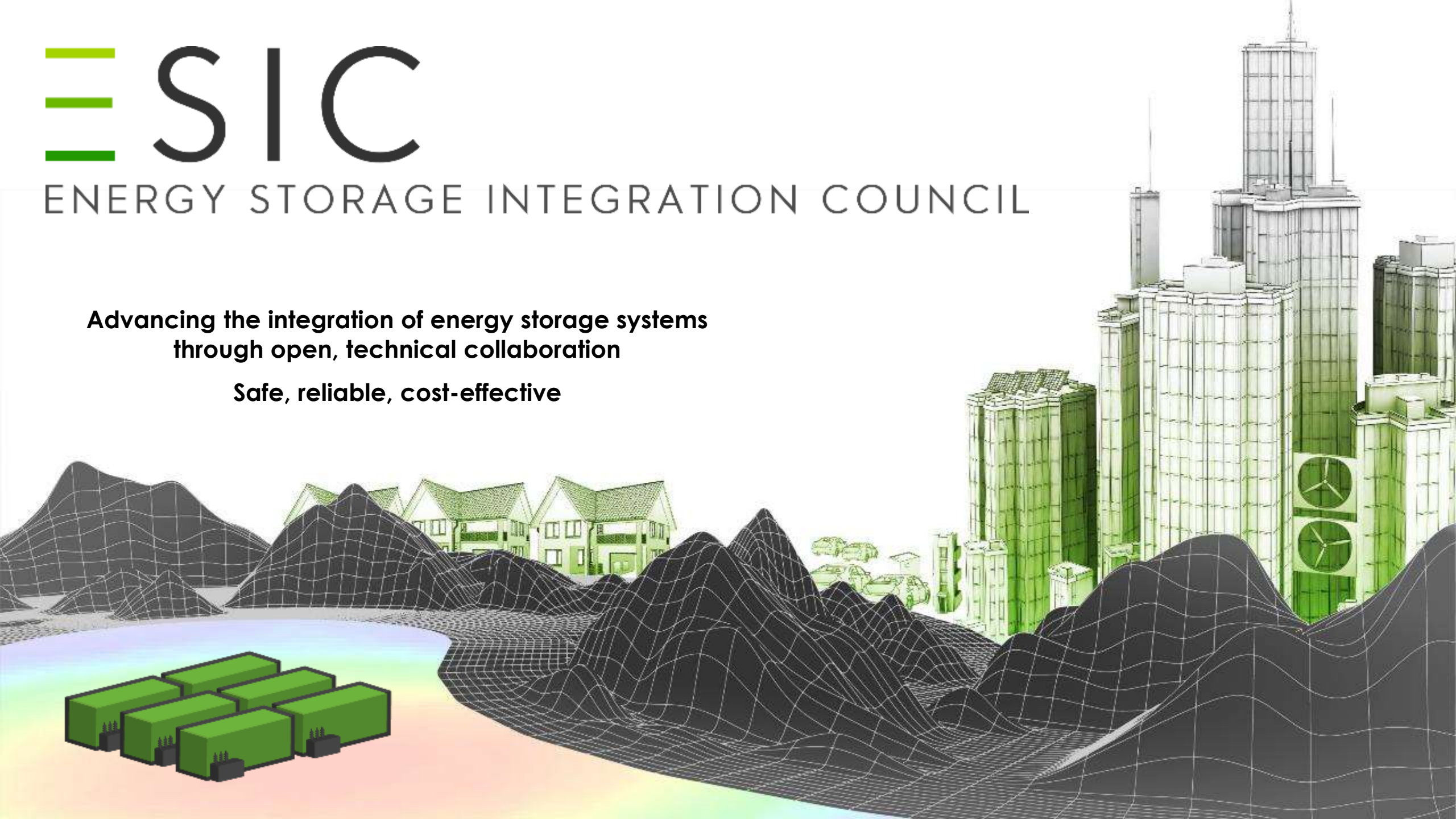
Energy Storage Integration Council

ESIC

ENERGY STORAGE INTEGRATION COUNCIL

Advancing the integration of energy storage systems through open, technical collaboration

Safe, reliable, cost-effective



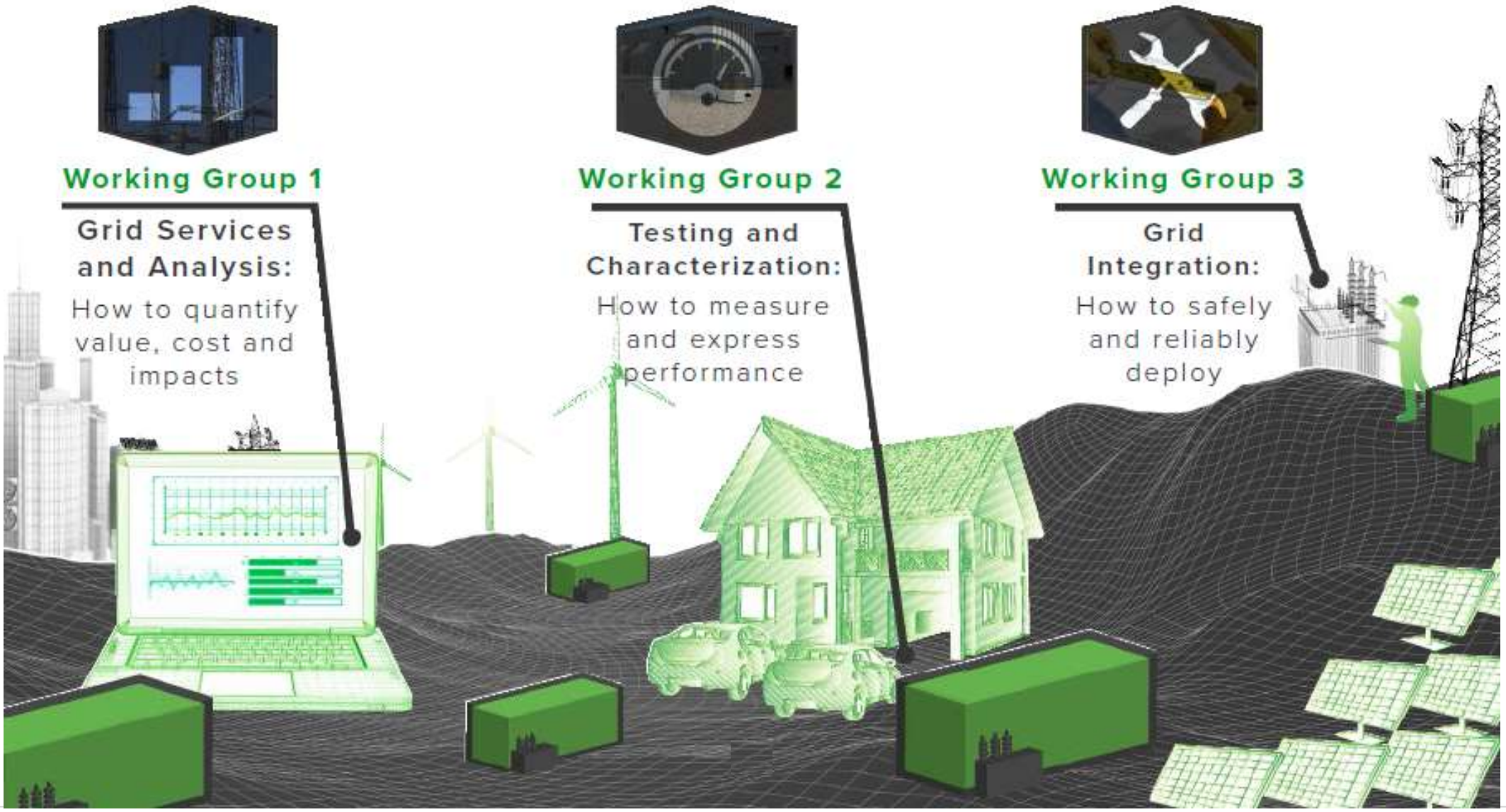
ESIC Objectives and Process

Identify industry needs, align on common approaches, publish guidelines and tools

Published products at ESIC website:
www.epri.com/esic

Working drafts on collaboration site:
https://collab.epri.com/esic (login required)

ESIC Working Group Structure and Engagement



ESIC Products Published to Date

Energy Storage Implementation Guide

For the latest ESIC products go to www.epri.com/esic

Working Group 1

- Energy Storage Cost Template and Tool
- StorageVET and supporting documentation (www.storagevet.com)
- Energy Storage Modeling Bibliography

Working Group 2

- Energy Storage Technical Specification Template
- Energy Storage Test Manual

Working Group 3

- Energy Storage Safety Guide
- Energy Storage Commissioning Guide
- Energy Storage Request for Proposal Guide
- Common Functions for Smart Inverters V4

Save-the-Date: Next ESIC General Meeting

- Discuss and prioritize technical challenges of energy storage integration
- Date: October 18, 2018
- Location: EPRI Offices – Charlotte, NC
- Co-located with 3rd annual ESA/EPRI Energy Storage STUDIO Technical conference
- To join e-mail list, send full contact information to esic@epri.com. See www.epri.com/esic for more information.

Last meeting - 4/17/18, hosted by National Grid in Waltham, MA

Contact Information

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